3.0 Identification and Screening of Technologies

This section identifies and screens technologies that address mine water management at Bunker Hill. Technology screening has been conducted and presented in earlier documents. This section summarizes and references that screening, and identifies technologies used to develop the remedial alternatives discussed in Section 4.

3.1 Description of Remedial Components

Mine water management has been broken into these six general components:

- AMD Mitigations / Source Control
- AMD Collection
- AMD Conveyance
- AMD Storage
- AMD Treatment
- Sludge Management

Figure 3-1 provides a generalized schematic of the six components. The AMD mitigations / source control component pertains to actions that could reduce the volume or improve the quality of the mine water. AMD collection consists of the method used to collect water within the mine and transport it to the mine portal. AMD conveyance consists of transporting the AMD from the portal to a treatment facility. AMD storage addresses the requirement to place AMD in a temporary holding area during those periods when the discharge flow rate from the mine exceeds the capacity of the treatment plant or when the treatment plant is inoperative. AMD treatment consists of changing the chemical characteristics of the mine water such that it is suitable for discharge to Bunker Creek and the SFCdA River. Sludge management consists of dewatering and disposal of sludge generated during the treatment process.

Each component is linked to the other components. For instance, successful mitigation / source control measures will reduce the volume of poor-quality mine water or improve the quality of the water. Lower volumes will reduce the demands on the collection and conveyance system, and reduce the amount of storage needed. Better-quality water will reduce the treatment demands and generate less sludge. The relationships among the components will be evaluated in later sections of this report. The following subsections identify technologies that could be applied to each component, and include a screening to identify the preferred technology options identified for each component.

3.2 Mitigations and Source Control

Several methods to mitigate and / or control the source of the AMD have been discussed, developed, tested and, in some cases, implemented during the past 30 years. This section provides a brief description of the steps used to identify and screen the mitigations so that the preferred mitigations could be carried forward into the feasibility study. Additional information may be found in the cited references.

3.2.1 Identification and Screening of Mitigations

CH2M HILL first reviewed and summarized potential mitigations during preparation of the presumptive remedy document (CH2M HILL, 1999d). The review included concepts developed during extensive research work done in the 1970s and 1980s by the University of Idaho, and concepts developed by a technical focus group including representatives from EPA, IDEQ, CH2M HILL, Terragraphics, the current mine owner, and other researchers. This included infiltration reduction options, mine flooding, air sealing and capping. All of these options, except infiltration reduction options, were screened from further consideration because of implementability and effectiveness problems. A summary of the mitigations evaluated and the screening rationale is as follows:

- **Surface Water Diversions**. These mitigations consisted of constructing diversions to intercept flow in the West Fork, South Fork, and mainstem of Milo Creek. Flow would be hard-piped around infiltration zones to a point downstream where the flow would discharge into the existing Milo Creek diversion system. These diversion options were considered implementable and effective and were retained for further evaluation. The West Fork and South Fork diversions were thought to have greater AMD mitigation potential compared to additional mainstem diversions.
- **In-Mine Water Diversions**. This technology approach consists of routing relatively clean water within the mine around known acid-producing areas such as the Flood-Stanly Ore Body. The workings are old and consist of numerous unmapped stopes, drill holes, and drifts that would require exploration to determine flow paths. Significant rehabilitation of the workings would be required to gain access to develop specific routing options for further evaluation, to estimate costs, and to determine effectiveness. This option was screened from further consideration because it was considered to have very high cost, difficult implementability, and unknown effectiveness.
- **Flooding the Mine**. This option consists of flooding the mine to reduce oxygen that is required in the chemical reaction for acid generation. This option was screened from further consideration because of high risk of uncontrolled leakage above 9 Level, it would severely limit or eliminate mining activities, and it would create a positive gradient of subsurface flow to the SFCdA River that could eventually contaminate groundwater or the river.
- **Air Seals**. This option consists of sealing adits, raises, and tunnels that are connected to the atmosphere such that oxygen would no longer be able to enter the underlying mine workings, thereby preventing the chemical formation of acid water. This option was screened from further consideration because it is not implementable given the magnitude of the underground workings and their connectivity to the surface.
- **Capping**. This mitigation consists of placing a low-permeability cap over areas of the mine to reduce infiltration. This technology would be very costly to implement over large areas because of the steep and densely forested terrain above the mine. However, it

could be applicable to smaller, selective areas such as over portions of the Flood-Stanly Ore Body. For this reason, capping over selective areas was retained for further evaluation.

Two of the mine water mitigations identified in the presumptive remedy document (South Fork of Milo Creek and West Fork of Milo Creek diversions) were carried forward into a cost/benefit analysis. The analysis estimated the cost of the mitigations and the savings in treatment that would be realized if the mitigations were implemented. The analysis demonstrated that the mitigations had potential to offset treatment costs, particularly if more costly technologies such as evaporation, ion exchange, or microfiltration were needed (CH2M HILL, 1999e). This finding led to the review of over 190 documents, papers, theses, maps, and reports in the project library with emphasis on 25 documents that focus on mine water issues (see Appendix A), and resulted in the identification of several other AMD infiltration reduction mitigation concepts. These were identified by the memorandum titled *Field Reconnaissance of Inflow/Recharge Mechanisms, AMD Generation Mitigations, Bunker Hill Mine Water Management Project* (CH2M HILL, 1999c), which included information obtained from an in-mine reconnaissance of the Flood-Stanly Ore Body (CH2M HILL, 1999b).

The additional mitigations identified during the field reconnaissance and in the presumptive remedy document were ranked during a stakeholder meeting, and summarized in the memorandum, *Ranking Summary of Next Step Mitigations* (CH2M HILL, 1999f). The ranking process considered several criteria, including effectiveness, implementability, and cost. The purpose of the ranking was to identify those mitigations that have a high potential to be successful. However, mitigations that were screened from further evaluation may be beneficial in the future, and should be reviewed after the higher-ranking mitigations are implemented and assessed in terms of actual effectiveness. A summary of the mitigations by basin area and the ranking results is as follows:

West Fork Milo Creek

- **West Fork Diversion**. As described above, a diversion structure or multiple structures would be installed in West Fork Milo Creek to collect flow in the creek. The structure(s) would be keyed into bedrock to intercept alluvial flows. The flows would be transferred into a pipeline that would route water down to the existing Milo Creek channelization system. This option was retained.

- **Surface Diversions above Guy Cave**. A road would be constructed above the caving area to intercept surface flows coming down the hillside to the Guy Cave or into fissures above the Guy Cave. A lined ditch on the inside of the road would be designed to carry flow along the road grade down to the mainstem channelization system, or to tie into the West Fork diversion pipeline or the diversion at the Phil Sheridan raises, if constructed. This option was retained.

- **Capping the Guy Cave.** The capping concept presented above was re-evaluated during the ranking process as two separate mitigations. The first mitigation consists of an engineered cap constructed to cover the flatter, accessible caving area (both upper and lower areas) to minimize the amount of precipitation and run-on entering the cave. Hillsides above the cave could be stabilized and graded to promote run-off. This option was screened from further evaluation due to limited effectiveness, and because the

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majority of water entering the Guy Cave Area is believed to be infiltrating through cracks and fissures that are recharged above the caving area.

- **Capping fissure areas**. The second capping option includes capping fractures and fissure areas along West Fork Milo Creek between the potential diversion and the cave area by surface grouting or by extending the Guy Cave cap up to the diversion. This option was screened out because of its very difficult implementability given the steep terrain, and due to limited effectiveness because very little flow was estimated to be removed from the mine.

- **Open Phil Sheridan Raises**. Sediment and other materials that have collected in raises No. 1 and No. 2 would be removed to allow flow down to the Phil Sheridan drift where it would be routed around the Flood-Stanly Ore Body. Collection structures would be built to direct flow to the raises, and a pipeline from the Phil Sheridan portal down to Mainstem Milo Creek would be constructed to convey the collected water. The collection structures would be keyed into bedrock. The Phil Sheridan tunnel floor would be sealed to reduce leakage through fractures in the floor. Two variations of this mitigation were discussed; one constructed in conjunction with the West Fork Milo Creek diversion, and one without. The size of the collection structures and pipelines would be smaller if they were constructed in conjunction with the West Fork Milo Creek diversion. This option was retained for further consideration.

- **New Inclined Drill Holes**. Holes would be drilled from the Phil Sheridan Raise and other suitable locations to dewater subsurface areas that contribute to Guy Cave subsurface inflow. The drill holes would be sloped to drain to a collection point, and piped to Mainstem Milo Creek. Depending on contact with sulfides and the resulting chemistry, it is possible that the collected water may require treatment. This option was screened from further evaluation because of its limited effectiveness in reducing flow to the mine, and because of the possible need for water treatment.

- **Homestake/Utz Near-Surface Diversion**. Roads with lined ditches would be constructed above the near-surface portions of the Homestake and Utz Workings. The ditches would collect surface flows above the workings and route them down and around the near-surface workings to Milo Creek. This option was screened out because of its limited effectiveness for reducing flow into the mine

- **Cemented Backfill**. The Homestake and Utz Workings would be backfilled with sand/cement grout to remove acid-producing voids, reduce heat generation, and reduce flow to lower levels of the mine. This option was screened out because of its limited effectiveness for reducing flow into the mine.

- **Surface Capping**. The hillside above near-surface areas of the Homestake and Utz Workings would be capped to reduce the amount of water available to infiltrate into the workings. This option was screened out because of its limited effectiveness for reducing flow into the mine.

South Fork Milo Creek

- **South Fork Diversions**. A diversion structure or multiple diversion structures would be constructed in South Fork Milo Creek similar to the West Fork Milo Creek diversion

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discussed above. The structure(s) would be keyed into bedrock, and water would be piped down to the Mainstem Milo Creek channelization system. This option was retained for further evaluation.

Mainstem Milo Creek

- **Improve Existing Diversion**. The existing upper diversion structure on Mainstem Milo Creek would be improved to reduce creek flow downstream of the structure. Two mitigation options were discussed: sealing and raising the weir, or increasing the capacity of the diversion and pipeline. The first option would include installation of a better seal along the bottom of the diversion structure and raising the weir to direct flow to the pipeline during larger storm events (the current weir is designed to accommodate a 2-year flow event). The second option includes increasing the size of the water intake in the diversion and the associated pipeline down to the second diversion structure to handle much larger flow events. Both these options were retained for further evaluation.

- **Upper Milo Diversion.** An additional diversion would be constructed above the existing upper diversion to divert flows from locations where the Cate Fault and Buckeye Fault are close to the mainstem. The water would be collected in a pipe and conveyed down to the upper diversion collection basin, or further downstream. This option was screened from further consideration because of the low potential for water quality and infiltration reduction improvements, and high cost.

- **Plug Small Hopes Drift.** Portions of the Small Hopes Workings that intercept flow from Mainstem Milo Creek would be plugged with a sand/cement grout or other suitable material. This would be done to eliminate the possibility of high stream flows eroding a direct flow path into the immediately underlying workings, and also to reduce infiltration. This option was retained.

- **Relocate Bunker Hill Dam.** The City of Wardner emergency water supply dam located downstream of the existing upper diversion on Mainstem Milo Creek would be removed or abandoned. Flow that is currently diverted from the upper diversion to the Bunker Hill Dam would be routed directly into the emergency supply pipeline. This option was retained.

Deadwood Creek

- **Plug/Bypass Inez Shaft**. The Inez Shaft would be located and dug out, and a concrete plug constructed to reduce the water infiltrating from Deadwood Creek, and to eliminate the possibility of high stream flows from eroding a direct flow path into the mine. Another option was discussed that would include sealing Deadwood Creek with grout in the vicinity of the Inez Shaft so that water coming down the creek bypasses the shaft. This option was retained.

Other Areas

- **Plug/Pipe Drill Holes**. Drill holes on the 7 Level (DDH #1208) and in the Russell Tunnel, East Reed Drift, Bailey Drift, Van Raise, and Cherry Vent would be sealed by installing packers in the drill holes. This option was retained.

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- **Fault/Hillside Dewatering**. Drill holes would be installed to dewater the area within the cone of depression for the mine. The holes would be sloped to allow collection at a central location, and water would be piped to Mainstem Milo Creek. This option was screened from further consideration because of the low potential for water infiltration reduction and water quality improvements.

Additional in-mine mitigations were introduced during a subsequent stakeholder meeting and addressed in the memorandum titled *In-Mine AMD Mitigation Strategies* (CH2M HILL, 2000e). These were as follows:

- **In-Mine Treatment by Liming.** This consisted of transporting lime into the mine and adding it to the AMD, with the sludge piped into a shaft for disposal into the mine pool. This approach was screened out because it would be more costly and less effective than adding the lime at an external treatment plant, plus disposal of sludge in the mine pool could rapidly fill the shaft and prevent it from being used for mining purposes.

- **Diversion of 9BS and 9BO Flows into the Mine Pool.** This consisted of collecting the relatively weaker mine waters within the mine and injecting them into the mine pool, with the goal that the mine pool would gradually become cleaner. This approach was screened out because it would increase the cost to pump and treat the mine pool. The pool would only be diluted, would still require treatment, and the treatment cost would not be reduced.

- **Diversion of Poor-Quality Water That Recharges the Mine Pool.** This consisted of collecting the relatively strong mine waters within the mine and separately piping them out to the surface with the goal that the mine pool would gradually become cleaner. This approach was screened out because it is very unlikely that all the sources could be identified because most the Flood-Stanly Ore Body workings are inaccessible. Even if this were possible, the mine pool would still need to be pumped and treated.

- **Collection of Poor-Quality Water and Discharge Below 14 Level.** This consisted of collecting the relatively strong mine waters within the mine and piping them to below the 14 Level in one of the mine shafts. The goal would be to use the potential anaerobic-reducing conditions to precipitate the metals as sulfides. This approach was screened out because there is potential to fairly rapidly fill the shaft with muck / sludge and prevent it from being used for mining purposes, as described in the technical memorandum titled *Bunker Hill In-Mine AMD Mitigation Strategy—Collection of Poor Quality Water and Discharge Below 14 Level* (CH2M HILL, 2000f).

3.2.2 Descriptions of Remaining Mitigations

Ten mitigations remained after the screening process described above. Conceptual designs and order-of-magnitude cost estimates were prepared for each. These remaining mitigations are described below. More detailed descriptions and a plan view showing the location of the mitigation options in Milo Gulch are included in Appendix C.

- **West Fork Diversion** – The purpose of this diversion is to reduce infiltration into the Guy Cave Area and the underlying Flood-Stanly Ore Body. A diversion structure or multiple structures would be installed in West Fork Milo Creek to collect flow in the creek. The structure(s) would be keyed into bedrock to maximize the interception of stream flows. The flows would be transferred into a pipeline via a grated inlet structure and perforated pipe drain buried in the upstream channel that would route water down to the Reed Landing area within the existing Milo Creek channelization system. The structure and pipeline would be designed to accommodate the 100-year, 24-hour rainfall with snowmelt event [57 cubic feet per second (cfs)], based on the Milo Gulch Hydrologic Analysis presented as Attachment A to the technical memorandum in Appendix C.

- **Rehabilitate Phil Sheridan Raises** – This proposed action would reduce infiltration through the Guy Cave Area and the underlying Flood-Stanly Ore Body. This action would also provide a backup to the West Fork Diversion, and would collect flows from portions of the west side of the basin, which are outside the capture zone of the West Fork Diversion. Sediment and other materials that have collected in Raises No. 1 and No. 2 would be removed to allow surface water and alluvial groundwater flows that reach the raises to flow down to the Phil Sheridan adit. Surface collection structures would be rehabilitated to help direct flow to raises No. 1 and No. 2. A new portal and drift would be constructed to route the collected water into the pipeline proposed for the West Fork Diversion. The hydraulic design capacity would be the 100-year, 24-hour rainfall with snowmelt event (21 cfs).

- **Upgrade Phil Sheridan Diversion** – In addition to the rehabilitation efforts at the raises and the new portal and drift described above, the ground adjacent to Raise No. 2 would be modified to collect more groundwater. The modification would consist of a grout curtain or similar barrier. No provision for cutoff to bedrock is currently considered for Raise No. 1, unless it is found that there is significant groundwater flow past the raise. The primary purpose of Raise No. 1 is to intercept surface runoff from the area outside the capture zone of the West Fork Diversion during high runoff events.

- **Sidehill Diversion -** A road would be constructed above the Guy Cave Area to intercept surface water flowing down the hillside to the caves or into fissures above the caves. A lined ditch on the inside of the road would be designed to carry flow along the road and discharge to the diversion at Phil Sheridan Raise No. 1. The road adjacent to the ditch would be used for ditch maintenance. A turnaround would be located at the far (northern) end of the road for maintenance vehicles. The Sidehill Diversion would complement the West Fork Diversion and the Phil Sheridan Raise system, and would also be designed for the 100-year, 24-hour rainfall with snowmelt event (19 cfs).

- **South Fork Diversion** – The South Fork Diversion would be similar in design to the proposed West Fork Diversion. A cutoff wall would be constructed to divert South Fork Milo Creek above the Buckeye Fault zone (in the portion of the creek that is perennial). The diverted flow would be piped downstream for discharge to the Reed Landing water collection structure. The diversion structure and pipeline would be designed to handle the 10-year, 24-hour rainfall with snowmelt event (76 cfs).

- **Plug Small Hopes Drift** – Portions of the Small Hopes Workings that lie near the surface below Mainstem Milo Creek would be plugged with a sand/cement grout or other suitable material. A vertical shaft would be installed adjacent to the Mainstem Milo Creek channel, and bulkheads would be placed within the drift below the creek bottom to isolate the backfill zone from other areas of the workings. A sand/cement backfill

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would be used to fill the isolated drift area. The primary purpose of this mitigation would be to prevent large creek flows from eroding a direct flow path into the mine.

- **Bypass Bunker Hill Dam** – The Bunker Hill Dam impounds water for diversion into an emergency drinking water supply pipeline for the City of Wardner. Water from the reservoir behind the dam may infiltrate into the underlying mine workings. The outlet gate would be opened and a grizzly screen placed in front of the gate. The dam and screen would help collect stream bedload to reduce the load on the downstream hydraulic structures at the Reed Landing. The City of Wardner emergency water supply would be hard-piped around the dam. This would eliminate the existing pool of water behind the dam.
- **Improve Existing Diversion** – There are two variations for this option. The objective of each would be to reduce the amount of water that overflows or leaks under the upper diversion structure on Milo Creek because the stream reach below may infiltrate water into the underlying mine workings. First, the existing upper diversion structure on Mainstem Milo Creek would be improved to reduce flow observed in the main stem below the structure. Improvements would include installing a better seal along the bottom of the diversion structure, raising the weir to direct more flow to the pipeline (the current weir is designed to handle a 2-year flow event), and improving the screen intake to reduce clogging for the intake pipe. In the second variation of this option, the capacity of the water intake of the diversion structure and the associated pipeline down to the second diversion structure (at the Reed Landing) would be increased to handle the 10-year, 24-hour rainfall with snowmelt event (172 cfs).
- **Plug/Bypass Inez Shaft** – For this option, the Inez Shaft would be located and excavated to bedrock, and a plug would be constructed using concrete to reduce the water infiltrating from Deadwood Creek. The primary purpose of this mitigation is to prevent large creek flows from eroding a direct flow path into the mine.
- **Plug Drillholes** –This option would plug drillholes on the 7 Level (DDH No. 1208) and in the Russell Tunnel, East Reed Drift, Bailey Drift, Van Raise, and Cherry Vent. The drillholes would be sealed by installing packers or other plugs. The purpose of this mitigation would be to reduce groundwater discharge from the underground drillholes into the mine.

Table 3-1 summarizes the mitigation options that were evaluated further by drainage basin.

3.2.3 Mitigation Effectiveness

Several criteria were used to screen the mitigation and source control measures, leaving the mitigations described above. One of those criteria was the effectiveness of the mitigations. Mitigation effectiveness is defined as either reducing the volume of water flowing through the mine, or improving the water quality. Mitigation effectiveness is closely linked with the other remedy components. For instance, if a mitigation can reduce the volume of water coming out of the mine, then the size of the treatment plant can be smaller as well. If a mitigation improves the quality of the mine water, less treatment is required, which reduces treatment costs and sludge management costs.

IDEQ, CH2M HILL, and previous University of Idaho researchers evaluated the water inflow reductions associated with mitigations considered in this study and documented them in the technical memorandum *Field Reconnaissance of Inflow/Recharge Mechanisms, AMD Generation Mitigations, Bunker Hill Mine Water Management Project* (CH2M HILL, 1999c). Table 3-2 summarizes the estimated reductions in flow and improvements to water quality developed by the analyses. These estimates are imprecise and in some cases constitute the best guesses of the expected reduction of inflow to the mine. In general, the analyses indicate that the proposed mitigations will be more effective at reducing peak mine flows than base flows. This is further discussed in Section 4.

It is difficult to estimate the effect of the proposed mitigations on mine water quality because the relationship between reductions in hydraulic load and acid or metal load is not well understood. Because of this uncertainty, a technical focus group, which included AMD experts from CH2M HILL, the U.S. Geological Survey (USGS), and former University of Idaho researchers, evaluated the potential effects of the proposed mitigation components on the discharge of AMD at the site. The focus group concluded that mitigation options that reduce hydraulic load are likely to reduce the lime or treatment demand and associated sludge production at the treatment plant. The reduction of lime demand and sludge production is expected to be greater for mitigations that reduce water inflow to acid-producing areas of the mine, with those reducing flow through the Flood-Stanly Ore Body being the most effective. The technical memorandum prepared by the focus group is included in Appendix B.

3.3 Mine Water Collection

Two options were considered for the collection of AMD within the mine. The first option was to continue with the current method of collection. Mine water flows by gravity from near-surface workings to the 9 Level ditch and out the Kellogg Tunnel portal. A portion of flow from the upper workings may bypass 9 Level and flow to the submerged workings where it is collected along with groundwater inflow. This requires pumping to the 9 Level ditch to maintain a steady water elevation in the mine. A second option was evaluated that included diverting all upper country flows to the submerged workings, and pumping the submerged workings from wells or a shaft installed from the Deadwood side of the mine to a new pipeline that flows to the treatment plant.

Both collection methods require that the mine infrastructure be maintained to allow access to the collection system for maintenance and periodic cleaning. In particular, the Kellogg Tunnel, the 9 Level East Drift , and the 9 Level workings on the west side of the mine must remain open and accessible into the future for mine water collection. Typical maintenance activities required for mine water control are associated with the surface facilities, rail system, hoisting facilities, electrical system, ventilation system, shafts, and drifts, as discussed in Section 2.2.3. If these maintenance activities are neglected, access to the underground workings and control of the mine water will be severely affected or made impossible.

Both options are described in more detail in the presumptive remedy document (CH2M HILL, 1999d). The second option was screened from further consideration in the presumptive remedy document because of the number of uncertainties associated with the diversion and pumping scheme, and the potential for greater costs and higher risk of failure.

Therefore, the existing collection procedures are carried forward into alternative development. A detailed description of the currently known in-mine water flow paths is presented in the report titled *Acid Mine Drainage – Bunker Hill Mine Water Conceptual Model* (CH2M HILL, 1999a) and summarized in Section 2 of this report.

3.4 Mine Water Conveyance

This component includes the conveyance of mine water from the Kellogg Tunnel portal to the treatment plant. During the spring of 1999, the AMD pipeline experienced a large decrease in capacity, and failed to convey all the mine water. This may have been caused by a buildup of muck inside the pipe that choked the flow. The capacity was reduced to about 1,400 to 1,500 gpm. The pipeline was replaced as part of an emergency action to maintain the flow of mine water to the lined pond. Figure 3-2 presents a plan view of the newly installed pipeline. A new concrete channel and flow measurement flume was installed outside the portal. A new buried 20-inch HDPE pipeline was installed from the concrete channel to the lined pond, which has 7 million gallons of storage capacity. The new concrete channel and pipeline have a capacity of about 7,000 gpm. An overflow manhole in the mine yard allows the mine water to be diverted out of the new pipeline into the old pipeline, as long as the flow is less than the capacity of the old line. This allows the new pipeline to be periodically inspected and cleaned.

From the lined pond, the mine water is pumped to the CTP using an existing pump station. A tee, which is currently closed by a blind flange, was placed in the new pipeline for a future connection directly to the CTP. Having the mine water flow directly to the CTP and bypassing the lined pond will reduce the accumulation of mine muck in the pond and will maintain more of its capacity for mine water. This will also reduce cleaning costs and costs associated with the pump station.

With the installation of the new concrete channel and pipeline, additional mine water conveyance options do not need to be considered. As part of the remedial alternatives developed in Section 4, the new pipeline will be used to convey mine water to the lined pond, and a new pipeline will be installed from the blind-flanged tee section to the CTP.

3.5 Mine Water Storage

AMD storage is required during those infrequent periods when the conveyance or treatment systems are inoperative, or when the Kellogg Tunnel portal discharge flow rate is higher than the treatment plant capacity. Three options for AMD storage were evaluated in the presumptive remedy document (CH2M HILL, 1999d): in-mine storage, storage in surface impoundments 16 million gallons and larger, and use of the existing lined pond. Surface impoundment storage was screened out, based on a cost comparison to in-mine storage and the limited availability of onsite land. The evaluation considered only the storage capacity necessary for CTP shutdown during maintenance and emergency situations.

Since that initial evaluation, an analysis of the effect that TMDL implementation in the SFCdA River will have on the long-term remedy was conducted and is described in Section 4. The analysis indicated that storage is not expected to be needed for achievement of the TMDL, but will be needed to temporarily store mine water flows in excess of the treatment capacity or when the plant is shut down for maintenance or repairs.

The existing lined pond has 7 million gallons of storage capacity if it were cleaned out. The existing capacity is estimated at about 5 million gallons because of accumulation of sediment and muck from the mine water. The current rate of muck accumulation is unknown. The average rate of accumulation since the lined pond was placed into continuous service (about May 1996) is about 450,000 gallons/year. A comparison of Kellogg Tunnel discharge total suspended solids (TSS) to CTP influent TSS data shows that about 100 mg/L of TSS accumulates in the lined pond for every liter of mine water placed in the pond. This is a serious problem that unless corrected will result in the lined pond being full of sediment and muck and unusable for mine water. A routine operating strategy of transporting flow directly to the treatment plant, rather than into the lined pond, would allow the sediment and muck to be continuously removed with the treatment sludge rather than accumulating in the lined pond. This could require the prior removal of material not compatible with CTP operations. The existing lined pond will be used for future storage needs and will be included in each of the alternatives.

The 7-million-gallon lined pond may not have sufficient storage capacity for extended treatment plant shutdowns or if the Kellogg Tunnel flows are significantly higher than treatment capacity. At a typical flow rate of about 1,500 gpm, the lined pond would provide 3.2 days of storage assuming it was cleaned out and empty to begin with.

Additional storage is available in the mine either above the existing mine pool or below, if the pool elevation was lowered by pumping. The elevation of the mine pool is currently kept at about 30 feet below the 11 Level at Raise No. 2, which contains the pumps and pipe column used to maintain the pool elevation. The average pumping rate is about 700 gpm. About 20 million gallons of storage is available from the current water elevation up to the floor of 11 Level. The mine currently uses this storage when Kellogg Tunnel flow reduction is needed by stopping the dewatering pumps and allowing the water level to rise. It takes about 2-½ hours from the time the pumps are shut off for the flow to decrease at the Kellogg Tunnel portal because of the time the approximately 10,000-foot-long Kellogg Tunnel takes to drain.

Additional in-mine storage is available for contingency or emergency use within the 11 Level drift and workings between 11 and 10 Levels. The estimated storage capacity between the floor of the 11 Level drift and the floor of the 10 Level drift is 190 million gallons (CH2M HILL, 1999d). The total storage available from 30 feet below 11 Level to the floor of 10 Level is approximately 210 million gallons. At a typical flow rate of 1,500 gpm, it would take more than three months to fill 210 million gallons of storage. This duration is sufficient to accommodate most foreseeable repair and maintenance activities and high peak flow events.

CH2M HILL reviewed the potential for AMD in the mine water pool to flow to the SFCdA River and reported the findings in the technical memorandum titled *Analysis of Bunker Hill Mine Pool and South Fork Coeur d'Alene River Hydraulic Relationships and Estimation of*

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Groundwater Travel Times (CH2M HILL, 1999g). The analysis concluded that mine water elevations could increase up to the 10 Level floor elevation (2,224 feet) with no net flux of mine pool water to the river.

Lowering the mine pool elevation could create additional in-mine storage, although it is very unlikely that more than 210 million gallons of storage would be needed. This additional storage would be more costly than storage above 11 Level because of the increased pumping height. The increased height would require more expensive pumps, more piping, and would consume more power. For these reasons, storage above the existing mine pool elevation of 30 feet below 11 Level is preferred and will be included in alternatives that require additional in-mine storage.

A system is needed to divert the mine water into the pool. Two methods were evaluated to accomplish the diversion. The first method is the pump system currently in place. Pumps are used to pump the water from the 9 Level drainage ditches into a pipeline installed in Raise No. 1. One pump system is installed in the 9 Level ditch downstream of Raise No. 2 (about 800 gpm capacity) and another in the Barney Drift upstream of the Barney Switch (about 250 gpm capacity) (Personal Communication, 2000). By using these pumps to divert flow into the mine pool, and by turning off the extraction pumps, a total of about 1,750 gpm can be held in the mine. The drawback of the existing system is that it would require pumps and electrical power; also, it may not have the capacity to divert high flows. With no backup power source for the mine, a power outage would make the pump diversion system inoperative.

The second diversion method is a gravity diversion system. Gates could be used to divert the ditch flows into the mine pool. One diversion would be needed for the east-side water, and one for the west-side water. East-side water would be diverted down a pipe installed in the No. 2 Raise. West-side water would be diverted down a pipe installed in a newly constructed raise, of through the existing Barney Vent Raise. The gravity system could operate manually if needed, and could be sized for high flows. Such a system could also be configured using overflow weirs to allow passive diversion of flows in excess of the treatment plant's capacity. A conceptual design for a gravity diversion system is described in Appendix D.

Upgrades to the existing mine pool dewatering system are needed to pump diverted water back up from storage in a timely manner. The existing 700-gpm system has insufficient capacity to pump both the steady-state water and the diverted water. The existing system uses a submersible pump hung in the mine pool. The submersible unit pumps water to a centrifugal booster pump mounted in No. 2 Shaft above the 11 Level drift, which then boosts the water into a third pump on the 10 Level, which in turns boosts the water into the 9 Level ditch. Storing water above 11 Level would require the submersible and booster pump with associated electrical gear to be removed prior to flooding; otherwise, they would be damaged. The submersible pump is rated to about 40 feet of submergence. The booster pump is not sealed for submersion.

The technical memorandum included in Appendix D describes an alternate mine pool pumping system that uses two 700-gpm submersible vertical turbine pumps. Two pumps would provide the capacity needed to pump both the steady-state and the diverted water. Two pumps would also provide an installed spare for the steady-state pumping if one pump required maintenance. These pumps could be installed below 11 Level and could pump the water directly to 9 Level without additional booster pumps. This would allow the water levels to fluctuate higher in the shaft because these pumps are rated for greater submergence pressure. The current electrical system in the mine would be upgraded to support pump operation. In summary, the following three storage options are carried forward into alternative development:

1. Existing 7-million-gallon-capacity lined pond.
2. Existing in-mine storage system that uses pumps to transfer up to 1,050 gpm into the mine pool, and the existing 700 gpm extraction pump system.
3. New gravity diversion system and new extraction system using two 700-gpm submersible pumps.

Implementation of in-mine storage as discussed in this document will require close coordination with the mine owner. The storage system should be developed to meet the needs of both ongoing mine operations and mine water control.

3.6 Mine Water Treatment

All mine water from the Kellogg Tunnel is treated in the CTP, which was initially placed into service in 1974 and has not been changed significantly since that time. The CTP uses lime neutralization to remove the acidity and to precipitate the metals, which are removed by gravity settling, forming a sludge. Significant CTP updates and improvements are needed for the following reasons:

1. **The plant is incapable of achieving the TMDL and all State of Idaho discharge requirements.** Process changes and additional equipment are needed to produce effluent that achieves the load-based discharge limitation established in the TMDL, and State of Idaho water quality standards.
2. **The plant produces a large amount of sludge that is costly to manage**. The treatment process needs to be altered to produce less sludge.
3. **The plant needs reliability improvements.** Much of the equipment and process controls are severely worn or no longer function. Equipment upgrades and replacement are needed to improve treatment flexibility and reliability.
4. **The plant operates inefficiently.** Most of the automated processes no longer function, necessitating manual operation and intervention that increase costs.

The required updates and improvements are fairly extensive and are summarized in the following sections. Appendix E describes the current condition of the CTP and required changes in more detail.

3.6.1 Changes Required to Achieve TMDLs and Water Quality Standards

Several technologies were considered to treat the mine water to levels established in the TMDL and State of Idaho water quality standards. A preliminary technology screening was conducted in the presumptive remedy document (CH2M HILL, 1999d). The screening process identified 11 options, ranging from upgrading the existing plant to using evaporation and crystallization technology to make deionized water.

Three technologies were selected for treatability testing because of their potential to produce effluent with low metal concentrations at the lowest cost. These three technologies, which would be added to the existing CTP, were iron co-precipitation, sulfide precipitation, and sulfide functional ion exchange.

The treatability testing was conducted in two phases. Phase 1 consisted of a proof-of-principle test conducted at laboratory scale using jar tests, and testing of the existing CTP effluent for dissolved metals. The purpose of Phase 1 was to determine the potential for each of the technologies to meet the TMDL treatment goals using Bunker Hill Mine water. The results showed that all three technologies worked relatively well in decreasing the amount of dissolved metals in the mine water, but sulfide precipitation was preferred over the other two. Sulfide functional ion exchange was eliminated because it would be significantly more costly, and iron co-precipitation was eliminated because it required a higher operational pH (more lime) and produced a less settleable sludge. The testing also indicated that with filtration, lime addition alone (no sulfide addition) at a pH of about 9 to 10 might sufficiently remove dissolved metals. The results of the Phase 1 treatability testing are summarized in the *Phase 1 Testing Results* report (CH2M HILL, 2000g).

Phase 2 testing was conducted at the CTP to assess the addition of sulfide precipitation and filters. Sulfide addition was tested by adding sodium sulfide into the effluent of the neutralization/aeration basin prior to the thickener. Filters were tested by diverting a portion of the thickener overflow through different types of filters. The CTP operational pH was set at 9.5 during the testing. Two types of media filters and two types of micro-filters were tested. The media filters were a mono-media consisting of plastic-coated glass beads, and a tri-media filter consisting of anthracite, garnet, and sand. The micro-filters were a polymeric membrane and a ceramic membrane. The test results are described in detail in the *Phase 2 Testing Results* report (CH2M HILL, 2000h).

The Phase 2 test results showed that all the filters were successful at reducing the suspended solids and total metals concentrations of the effluent below target goals calculated from TMDL loadings, and that sulfide addition was not needed. The tri-media filters were found to be the preferred filter type. The media is widely available from many sources, and this type of filter is commonly used in many water and wastewater applications. Use of the plastic-coated glass bead mono-media would require periodic regeneration to replace the coating, and this type of media is less widely available. The micro-filters were prone to rapid plugging, which would require considerable cleaning and maintenance.

Based on the treatability testing, the anticipated typical CTP effluent concentrations of cadmium, lead, and zinc are shown below. These assume an operational pH of 9.5 and use of tri-media filters.

Anticipated CTP Effluent Concentrations

- Cadmium = <0.7 µg/L
- Lead = <1.0 µg/L
- Zinc = <70 µg/L

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The treatability testing also indicated that lower effluent concentrations for cadmium could be achieved by adding sodium sulfide after the neutralization reactor, or by adding a flocculent prior to the filters. However, the test results indicated that these enhanced treatment techniques will not be needed, but they could be considered for future implementation if additional metal removal is desired. Thus, the treatment process carried forward into alternative development is lime neutralization high-density sludge treatment using tri-media filters. The technical memorandum in Appendix E describes proposed changes to the existing CTP.

3.6.2 Changes Required to Make Less Sludge

The CTP is configured as a high-density sludge (HDS) plant. Lime is added to thickened sludge, which is then mixed with the plant influent. Dissolved metals precipitate and settle, forming sludge, and treated water is discharged to Bunker Creek. However, the plant is currently operating in low-density sludge (LDS) mode because the plant does not have filters (required when operating in the HDS mode) to remove suspended solids from the effluent. In the LDS mode, the plant produces a waste sludge of about 1 to 5 percent solids by weight. The HDS mode of operation is preferred because the waste sludge is expected to be about 20 to 25 percent solids by weight, which is expected to dewater to about one-half to one-third the final sludge volume compared to sludge dewatered in the LDS mode. Addition of filter equipment will allow the plant to be operated in the HDS mode.

3.6.3 Changes Required to Increase Reliability

During original CTP process development and design in 1973, the Bunker Hill Company acknowledged the potential for the CTP to experience upsets and breakdown, as summed up in the following statement, “The central impoundment pond will provide surge holding capacity during treatment plant upsets or breakdowns, thereby protecting the quality of the river course at all times” (Baker and Larson, 1973).

With the installation of the cover system, the CIA can no longer be used for mine water storage as was historically done. Thus, to provide protection from CTP upsets or breakdowns, either replacement storage is needed, more backup and redundant treatment capability is needed, or both. Use of both is expected to be more protective and cost-effective.

The CTP master plan in Appendix E describes recommended CTP modifications to cost-effectively reduce upsets or breakdowns. When coupled with emergency in-mine storage and storage provided by the lined pond, the likelihood of discharge of untreated mine water is considerably reduced.

The proposed upgraded treatment plant as described in Appendix E will include the following backup and/or redundant contingency systems. The specific size and capability of each will be determined during design and through completion of a failure modes and effects analysis (FMEA).

Backup Power. The current CTP does not have backup power. A diesel engine-driven generator will supply backup power to all essential treatment systems and work areas. The generator will be switched to start automatically if power supply from the electric utility is lost.

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Lime Feed System. Without the ability to make and use lime slurry, the CTP cannot function. The current, inefficient lime makeup and feed system lacks redundancy. Failure of the single lime storage silo, single aspirator system, and single lime slurry tank mixer would shut down the CTP. Also, it is unlikely that the semi-manual lime slurry makeup system could keep up with high lime demands resulting from very high mine water flows. There are also no functioning indicators or alarms to alert the operators of lime makeup or feed problems, other than loss of treatment process pH control (which is too late to prevent process upsets). The current method of pH measurement, coupled with the long retention time in Reactor A and the poor mixing in Reactor B, results in inability to control process pH in Reactor B more accurately than one-half a pH unit. Finer pH control would result in more consistent lime feeding and treatment. To address these shortcomings, the lime feed system will be improved to provide redundancy and sized for large lime demand loads in the event of a mine flood or flushing event that is not stored. This will include two lime silos, two lime slakers, two lime slurry tanks, and two lime slurry recirculation and feed systems.

Large Hydraulic Throughput Capacity. The hydraulic throughput capacity of the CTP will be sized for large flows (approximately 5,000 gpm) to enable flows up to 5,000 gpm to be neutralized and the metals precipitated. This can be done at little incremental cost because the existing CTP piping must be replaced for the new process equipment. This will help ensure that the flows can be managed without overflowing process equipment, and will reduce future costs if later capacity increases are required.

Backup and Redundant Control System. The existing antiquated and mostly inoperable control system will be replaced with a modern computer-based process control and operator interface system. This new system will be installed on redundant computers. The software will be backed up and will be re-installable from a remote computer via modem.

On-Hand Inventory of Critical Spare Parts. Critical spare parts will be stored at the plant and available for rapid installation.

3.6.4 Changes Required to Improve Efficiency

Today, as it was 27 years ago when the CTP was constructed, lime neutralization is still the most cost-effective way to treat the mine water. Use of the HDS process is also the most cost-effective way to reduce sludge volumes. Use of tri-media filters and a pH setpoint of about 9.5 is the most cost-effective way for achieving the TMDL discharge allocations. Maximizing use of existing CTP equipment and infrastructure to the most practical extent possible will minimize the cost to upgrade the CTP to achieve the TMDL, minimize sludge production, and provide more reliable treatment. Cost-effectiveness and reliability would also be improved by adding modern automated systems for process control and monitoring, lime slurry makeup, and polymer makeup.

3.6.4.1 Automated Process Monitoring and Control System

The CTP uses the original panel-mounted process control devices installed in 1974. Most of these antiquated process controls no longer function. Other than pH control and annunciation of certain alarms, there is no automation in the existing control system. Paper for the strip chart recorders is no longer manufactured.

The existing system does not have the flexibility and capability to support new equipment. The system is non-computerized and inefficient. A modern system would be considerably more reliable, efficient, and flexible.

A new automated programmable logic controller (PLC) -based system is needed. This system would automatically monitor system performance, control all pumps and mixers, automatically initiate lime and polymer make-up, record vital record-keeping information (such as flow and effluent metal load), and provide AutoDial alarm functions when needed. The control system would allow the plant to run unassisted overnight or on weekends, depending on the degree of autonomy desired.

A new personal computer will serve as the human-machine interface (HMI). The operator can view each unit process on the computer screen and know the status immediately. Software changes can also be made using the HMI. The HMI can be assessed both at the plant and remotely, and can provide automated reports. This system would track river flow at the Pinehurst gauge, enabling daily automatic calculations required to determine allowable discharge quantity for achieving the TMDL discharge allocations for the CTP.

3.6.4.2 Automated Lime Slurry Makeup and Feed System

The CTP uses lime slurry to neutralize the acidity of the influent and to precipitate the dissolved metals. The CTP uses more costly hydrated lime rather than quicklime because the CTP does not have an operational lime slaker, which is needed to automatically convert the less expensive quicklime to hydrated lime.

The economics of lime usage favors use of pebble quicklime rather than hydrated lime (about a 40 percent savings), slaking at the treatment plant to form hydrated lime, and then automatic slurring and feeding of the hydrated lime into the treatment process. Automatic slaking, slurrying, and feeding are usually performed because the initial capital cost of the equipment is recuperated in labor savings. For these reasons, the CTP initially used quicklime and a slaker for lime slurry preparation. The slaker is currently inoperative and is no longer used. The less-efficient and more costly semi-manual makeup system is used instead. An automatic system would provide more reliable and cost-effective operation.

3.6.4.3 Automated Polymer Makeup and Feed System

Polymer solution used to help settle the suspended solids in the sludge thickener is currently manually made up by adding dry polymer to water in a polymer make-up tank. Polymer dosage is evaluated by observing the settling rate of samples of thickener feed and effluent turbidity, and is adjusted by changing the speed of the feed pump. The current manual make-up system is labor-intensive. There are no alarms to alert the operators of problems, or if the polymer storage tanks are getting low. An automated polymer make-up and feed system would reduce manpower requirements, allow more efficient use of polymer, and increase worker safety.

3.7 Sludge Management

Lime neutralization treatment of AMD results in sludge generation. The sludge consists of entrained and chemically bound water and the precipitated metals removed from the AMD. The major constituents are water, and oxides and hydroxides of iron, zinc, manganese,

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magnesium, and aluminum. Gypsum can also be a major constituent depending on the concentration of sulfate in the AMD, which varies seasonally. The sludge also contains oxides and hydroxides of the contaminants of concern, including lead and cadmium. The sludge is brownish in color, resulting from a combination of the yellowish-orange hues from the iron oxy-hydroxides, and the dark brown to black hues from the manganese oxides.

The CTP currently generates sludge consisting of 1 to 5 percent solids. Sludge is pumped daily from the thickener into the unlined sludge disposal bed on the CIA (Figure 3-3), which has about 3 to 5 years remaining capacity. On average, about 140,000 cubic yards (yd^3) of sludge per year are pumped to the CIA. The entrained water slowly drains from the sludge, leaving behind about 15,000 to 20,000 yd^3 of sludge per year. Sludge produced by the HDS plant will average about 20 to 25 percent solids by weight when pumped from the thickener, compared to the existing 1 to 5 percent. On average, this equates to about 20,000 yd^3 of liquid (raw) sludge per year needing to be further dewatered and disposed of, compared to about 140,000 yd^3 in the existing LDS process. The existing sludge passes the toxicity characteristic leaching procedure (TCLP) test, is exempted as a Bevill-excluded waste as described in Section 2.6, and is therefore not classified as hazardous waste. The HDS sludge is also expected to pass the TCLP test and will be Bevill-excluded.

Several HDS sludge dewatering and disposal options were evaluated in the presumptive remedy document. The options were evaluated by general management categories of raw (liquid) sludge disposal, sludge dewatering, dewatered sludge disposal, and metal recovery.

3.7.1 Raw Sludge Disposal

Raw sludge can be disposed of in onsite disposal beds, similar to the current practice, except that the filtrate (water that drains from the sludge) would be collected and treated. Sludge from the CTP thickener would be pumped into the beds every day or every few days. These beds, which would be located on the southeast end of the CIA near the CTP (see Figure 3-3) or above the smelter closure area (Figure 3-4), would both dewater and permanently store the sludge. It is estimated that the HDS sludge would dewater to about 60 percent solids by weight, and would accumulate at about 5,400 yd^3 per year. One disposal bed would be constructed at a time and used for about 10 years. Therefore, three beds would be needed for a 30-year period. Each bed would require about 6 acres of land when in use. If LDS sludge were disposed of, about 20 acres would be needed for each of the three beds--about three times the disposal volume of the HDS sludge. When the first bed approaches capacity, a second bed would be built adjacent to it. Each full bed would be covered with an impermeable cover system and planted with grass. Additional information on how the disposal beds would be constructed and operated can be found in the presumptive remedy document (CH2M HILL, 1999d).

Disposal of raw sludge in the mine was also evaluated in the presumptive remedy document. This option was screened out because no suitable locations could be identified. However, in-mine sludge disposal may be appropriate for use by a future mine operation that uses a sandfill system for in-mine tailings disposal. The sludge could be incorporated into the sandfill.

3.7.2 Sludge Dewatering

Two methods to dewater sludge were evaluated in the presumptive remedy document; these were mechanical dewatering using belt filter presses, and gravity dewatering using sludge drying beds. Plate and frame presses could also be considered if mechanical dewatering is chosen.

The mechanical dewatering equipment would be located at the CTP and would dewater the sludge by mechanically induced draining and compression. The dewatered sludge, known as sludge cake, would be placed into trucks and hauled to a landfill. The drawback of belt filter presses or other mechanical dewatering processes is that they are complex and expensive machines that require close operator attention. However, they require less space than sludge drying beds.

Sludge drying beds would remove water through gravity drainage and evaporation from open-air impoundments similar to the sludge disposal beds described previously. Two drying bed cells would be constructed on the CIA in the area shown on Figure 3-3 for the sludge disposal beds. These two drying beds would be alternated yearly. This would allow time for the sludge to dewater, time for annual sludge removal, and time for reconditioning the sludge bed for the next year’s use. The filtrate from the beds would be collected and treated. The drawback of sludge drying beds is that they would require about 3 acres of land. The benefit is that they are very simple and require little operational oversight when compared to the mechanical dewatering equipment.

3.7.3 Dewatered Sludge Disposal

Dewatered sludge disposal options evaluated in the presumptive remedy document included in-mine disposal, or in onsite or offsite landfills. The Hanna Stope, which is a relatively large man-made cavern, was identified as having the highest potential for in-mine disposal. This would involve trucking the dewatered sludge up into Milo Gulch into 5 Level, where the stope is located. This option was screened out because it would be difficult to implement, its effectiveness is questionable, and its cost would be high. To contain the sludge, several plugs would need to be placed in drifts and raises that connect in the stope area. These plugs would be subjected to potentially very high forces from the sludge. This option would be difficult to implement because of the hazardous access to the Hanna Stope and loose rock areas, both conditions making the work dangerous. The effectiveness of this option was questionable because it would be difficult to keep the sludge isolated from mine water and from being displaced or dissolved. The cost was high because of the implementation problems and the costs of monitoring, which would be necessary to ensure the sludge was not being displaced or dissolved by the mine water.

Onsite landfill disposal was evaluated using landfills constructed in gulches or on flat areas within the site. Gulch areas were screened out because they were more costly than flatter areas and more at risk from being damaged by floods. The location considered for an onsite sludge landfill is above the smelter closure area (see Figure 3-4), which is one of the areas considered for raw sludge disposal using disposal beds.

Disposal of sludge in offsite landfills would not require the use of site land. Because the sludge is not a hazardous waste, it could be disposed of in Subtitle D (non-hazardous waste) landfills, such as in Airway Heights, Washington; Roosevelt, Washington; or Arlington,

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Oregon. Because sludge drying and hauling is required, offsite landfill disposal is more costly.

3.7.4 Metal Recovery

Recovery of zinc and manganese from the sludge using sludge leaching and electrowinning was evaluated. The process has been demonstrated at bench-scale by research conducted at the University of Idaho. However, considerable work is needed to develop and demonstrate full-scale capability; thus, the implementability, reliability, and long-term cost-effectiveness of the process is unknown. Economic feasibility would also fluctuate with changes in metals prices. Because of these unknowns, the process was screened out but may be considered in the future if the technology effectiveness and cost-effectiveness are demonstrated.

3.7.5 Sludge Management Screening Summary

Four sludge management options remain and are carried into Section 4 for development of alternatives. Two use raw sludge disposal and two use dry sludge disposal, and are summarized below.

Option A: Disposal of raw sludge in onsite sludge disposal beds located on the CIA that both dewater and permanently store the sludge

Option B: Mechanical sludge dewatering and disposal of dry sludge in an offsite landfill.

Option C: Disposal of raw sludge in onsite sludge disposal beds located above the smelter closure area.

Option D: Sludge drying using sludge drying beds and annual excavation and disposal of dry sludge in an onsite landfill located above the smelter closure area.

3.8 Summary of Technology and Option Screening

The technologies remaining for each remedy component are summarized in Table 3-3. These are assembled into alternatives in Section 4.

TABLE 3-1
AMD Mitigation Options
Bunker Hill Mine Water RI/FS Report

Drainage Basin	AMD Mitigation Option
West Milo	West Fork Milo Creek Diversion
	Rehabilitate Phil Sheridan Diversion
	Upgrade Phil Sheridan Diversion
	Sidehill Diversions
South Milo	South Fork Milo Creek Diversion
Mainstem Milo	Plug Small Hopes Drift
	Bypass Bunker Hill Dam
	Improve Existing Diversion
Deadwood	Plug Inez Shaft
Other	Plug Drillholes

TABLE 3-2
Estimated Mitigation Effectiveness in Terms of Reducing Water Inflow to the Mine
Bunker Hill Mine Water RI/FS Report

AMD Mitigation Option	Rough Estimated Average Flow Reduction (gpm)	Rough Estimated Peak Flow Reduction (gpm)
West Fork Diversion	240[a]	2,000[b]
West Fork Diversion w/ Phil Sheridan Raises	300[a]	2,000[b]
West Fork Diversion, Phil Sheridan Raises, & Sidehill Diversion	340[a]	2,240[b]
South Fork Diversion	100 – 120[b]	200[b]
Plug Small Hopes	60 – 90[b,c]	60 – 90[b,c]
Bypass Bunker Hill Dam	30 – 60 [b,c]	30 – 60 [b,c]
Improve Existing Diversion (both improve seal and increase capacity options)	90 – 150 [b,c]	400[b]
Plug/Bypass Inez Shaft	100[b]	800[b]
Plug Drillholes	260[d]	260[d]

Notes:
[a] Based on basin area x average annual precipitation in Kellogg.
[b] Based on best guesses developed during the September 22, 23, and 28, 1999, Field Reconnaissance of Recharge/Inflow Mechanisms, and refined during the September 29 and 30, 1999, Ranking Meeting and the December 16, 1999, Mitigation/Treatment Evaluation interim meeting.
[c] Based on Trexler's research work through the University of Idaho in Mainstem Milo Creek.
[d] Based on 150 gpm from DDH #1208, 45 gpm from Russell drillholes, 25 gpm from East Reed drillholes, 25 gpm from Bailey drillholes, 5 gpm from Van drillholes, 10 gpm from Cherry Vent drillholes.

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TABLE 3-3
Remedy Components for Alternative Development
Bunker Hill Mine Water RI/FS Report

AMD Mitigations	AMD Collection	AMD Conveyance	AMD Storage	AMD Treatment	Sludge Management
West Fork Milo Creek diversion Rehabilitate Phil Sheridan raises Plug in-mine drillholes Plug Small Hopes Drift below Mainstem Milo Creek Plug/bypass Inez Shaft below Deadwood Creek Sidehill diversion in West Fork Milo Basin South Fork Milo Creek diversion Bypass Bunker Hill Dam in Mainstem Milo Creek Improve existing diversion in Mainstem Milo Creek Upgrade Phil Sheridan Raise system in West Fork Milo Basin	Continue to use the existing approach, which consists of gravity-draining the combined upper levels water and pumped mine pool water out the Kellogg Tunnel.	Use the existing portal concrete channel and buried pipeline to lined pond. Install tee pipeline for direct flow to CTP	Surface Storage: Use the existing 7-million-gallon lined pond. In-Mine Storage: Use the existing system, or replace it with new gravity diversions and mine pool pumps.	Update and upgrade the existing lime neutralization HDS treatment plant. Add tri-media filters.	Option A: Sludge disposal beds on CIA that dewater and permanently store the sludge. Option B: Mechanical sludge dewatering and disposal of dry sludge in an offsite landfill. Option C: Disposal of raw sludge in onsite sludge disposal beds located above the smelter closure area. Option D: Sludge drying using sludge drying beds and annual excavation and disposal of dry sludge in an on-site landfill located above the smelter closure area.

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